THE WESTERN AUSTRALIAN
NATURALIST

Vol. 10 JANUARY 1, 1967 No. 4

NATURAL WOODLAND IN KING'S PARK, PERTH

By J. S. BEARD, D.Phil., King's Park and Botanic Garden, Perth, Western Australia.

432 acres of land on Mount Eliza, overlooking the Swan River, were reserved in 1872 "for the purpose of a public park and recreation ground." The area was extended to approximately 1,000 acres in 1890, and today (with minor alterations to boundaries) stands at 996 acres. The original title of "PERTH PARK" was changed to "THE KING'S PARK" in 1901.

Beautification and the development of civic amenities was commenced in 1895, but about four-fifths of the area, that is, about 800 acres, still remains under natural woodland—natural in the sense that it is self-sown and has not been artificially cleared or planted, but not virgin in the sense of an undisturbed climax vegetation which has remained unchanged for centuries. In spite of certain popular sentiment which likes to regard King's Park as "unspoiled virgin bushland," the plain fact is that the bush of the Park has become severely degraded during the present century. Everywhere large old forest trees stand stagheaded or dead and there are no vigorous young ones of the same species to replace them. To the most casual observer it is apparent that a former tall, open woodland dominated by eucalypts is in process of replacement by a low dense woodland consisting mainly of banksia and casuarina. In 1965 a detailed study of a small area of 16 acres of the park was made, in order to reconstruct a picture of the original eucalypt stratum from relics which still remained; to obtain accurate data on the structure and composition of the present woodland; and to endeavour to understand some of the degradation processes at work.

King's Park is so well known that no preliminary description of conditions affecting its ecology should be necessary. It may be useful, however, to cast a glance at the principal types of vegetation found on the Swan Coastal Plain, of which the Park forms a part. Woodland types predominate and a series can be traced related to increasing age and leaching of the soil from the coast inland. Near the coast stands of *Eucalyptus gomphocephala* (tuart) occur, usually on ridges, where the stand is dense, canopy almost closed and there is a sparse understory of small trees and large shrubs consisting mainly of wattle (*Acacia cyanophylla* and *A. spp.*) and *Xanthorrhoea*. Height of the eucalypts may attain 100 feet and the soil is a deep yellow sand with irregular projections of hard lime-

stone. This is the finest woodland on the coastal plain. On rather more leached soil, height is reduced to 60-80 feet, the tuarts becoming sparser and mixed with *Eucalyptus marginata* (jarrah) and *Banksia* and *Casuarina* appear in the understory. This is the King's Park type.

The next community along a scale of reduction with increasing leaching of the soil is to a pure jarrah overwood 50-60 feet in height with a well-developed lower layer of *Banksia* and *Casuarina*. This type again merges into a more reduced one 25-30 feet tall mainly of *Banksia attenuata* and *B. menziesii* with occasional specimens of *E. todtiana* which barely emerge above the general canopy. This last type is found essentially on deep white sands of coarse texture in which leaching of nutrients and the finer soil fractions has proceeded to an extreme and water-holding capacity has become extremely low. The same type of vegetation is also found locally on limestone outcrops carrying little or no soil where moisture is equally a critical factor.

It would be natural, where any one of these types of plant community had been damaged or destroyed, for it to be replaced at least temporarily by a different one resembling another related community further down the scale, in the series representing a deterioration within the same general type of habitat. The writer has observed that this is frequently the case with disturbance communities in other parts of the world. Thus we should expect that a general collapse of the ecosystem of the King's Park eucalypt woodland would lead to its replacement by a lower growth of the more tolerant *Banksia* and *Casuarina*, resembling in physiognomy the *Banksia-E. todtiana* type

THE STOCKTAKING SURVEY

The area chosen is shown in Fig. 1 and was a part of the Park

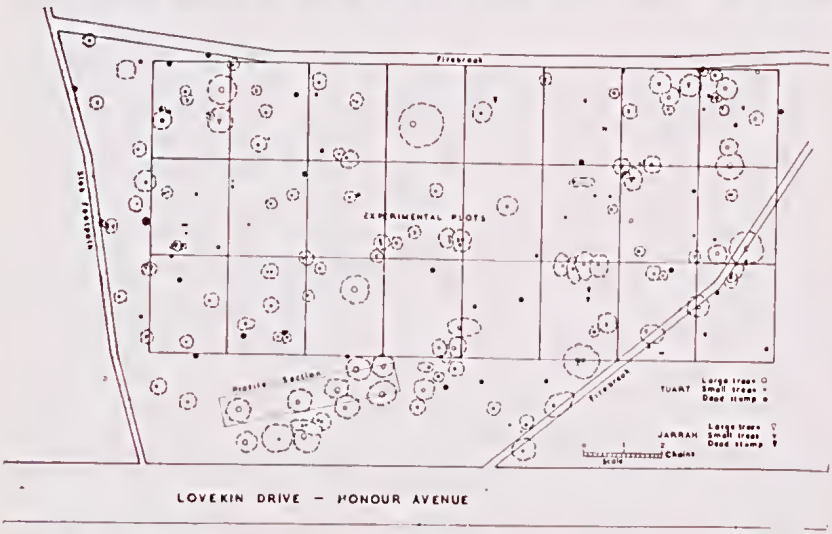

Fig. 1.—Plan of area studied with positions of trees plotted.

in whieh 24 x ½ aere plots had been laid down for an experiment in vegetation management. The existenee of the plot boundaries faeilitated plotting of the positions of the ineluded trees, and the data reeorded would also in the long run prove useful in the experiment itself. In addition to the plot area of 12 acres, about 4 acres of ground between the plots and Lovekin Drive and a nearby slab traek were also ineluded. Within this total area, the position of all eucalypt trees, living or dead, was plotted, with a record of species, diameter, height and eondition of the tree. The smaller and more numerous banksia and casuarina trees were not plotted, but instead the total number of eaeh was counted in eaeh of the ½ aere plot areas. Considering first the eucalypt population, only two speeies are present, tuart and jarrah, in the proportion of 3 : 1. Of the large trees 18 in. diameter and over, 84% are tuart, but the proportion of these is less among the small trees (65%). Large jarrah may have been felled and sawn by early settlers, leaving only inferior coppiee to replaee it; or alternatively, tuart may always have been preponderant. Distribution is irregular, and a pattern is notieeable of alternation of relatively dense groves of large-sized tuart without jarrah and areas of smaller trees where the two species mix. It is supposed that this is due to soil eonditions.

In order better to illustrate strueture of the stand and its deterioration, a profile was measured in the study area 300 feet long and 50 feet deep, and this is shown in Fig. 2 with the stand as it appears today contrasted with a reconstruction showing the existing trees in full canopy. The profile was not selected at random but was chosen to include as many large trees as possible in order to dramatise the degradation of the stand. The profile is actually more densely stocked with eucalypts than the average of the study area and correspondingly understocked in the lower story.

Fig. 2.—Measured profiles of tuart woodland in King's Park.

It is possible to say in general, however, that originally the woodland consisted of an open stand of large, spreading trees, the dominants averaging 60 ft. in height with some reaching 75 ft. or 80 ft. and 2-3 ft. in diameter with some reaching 5 ft. These trees branch or fork low down usually between 5 ft. and 15 ft. above ground and the branches spread widely. Owing to the bad condition of the surviving trees it is difficult to obtain an exact figure for crown spread, but many of the better dominants spread to 30 ft. to 50 ft. in radius from the butt. Between the large dominants a slightly smaller number of smaller trees is found reaching 50 ft. in height and 18 in. in diameter which are thought to represent suppressed trees growing in the vicinity of old dominants and partly young trees on their way up in gaps; with the general deterioration of the stand any young trees seem to have stagnated also, and died back so that the normal process of regeneration has been arrested. This applies also to saplings and seedling regeneration. The condition of the 194 eucalypt trees (144 tuarts and 50 jarrahs) recorded in February 1965 is shown in the accompanying table.

	Dominants			Small trees			Total	%
	t*	j*	all	t*	j*	all		
Full foliage	0	1	1	3	4	7	8	4
Stagheaded	11	8	19	20	16	36	55	28
Died back to 1/3-2/3 of height	15	0	15	4	2	6	21	11
Died back to 0-1/3	16	0	16	10	4	14	30	16
Died back to base	18	2	20	13	4	17	37	19
Dead	24	5	29	10	4	14	43	22
Totals	84	16	100	60	34	94	194	100

*t—tuart; j—jarrah.

Stumps of all trees that had died in recent years were located and recorded as far as possible but some may have been missed. On the record, of 194 trees 43 (22%) have died completely and only 8 (4%) retain something like full vigour. The rest are in various stages of dieback. The jarrah have tended to remain in better condition than the tuart, 50% of all jarrah being recorded as stagheaded only, and 10% as in full foliage; all the same their general appearance is poor and it is probable that little or no growth is being made. In the same way small trees have tended to retain vigour longer than dominants and there is a relatively large number in the stagheaded class.

The symptoms of recession in these trees are a progressive dieback of the crown; foliage is confined first to epicormic growth on the branches (stagheaded), later on main limbs only, later still on the lower part of the trunk, and on coppice shoots arising from the stump, until finally death supervenes. Basically the trouble is an inability to restore foliage lost through bushfire or borer attack, which suggests weakening of the tree by some other cause. A small proportion of living trees are fire-scarred at the base, and some on being felled are found to have termites active in the heartwood but

neither of these can contribute in a general way to the weakening of the stand.

It is possible to work out from the data the area of eucalypt crown cover which still remains, though to compare this with the original stand is more difficult. The total crown area of the living eucalypt trees at the present day is estimated at 7060 sq. yds., or 9% of the area of 16 acres. Stand density, with 194 trees on 16 acres, is 12 per acre, 6 of these being dominants and 6 smaller trees. Owing to the falling away of the limbs of half-dead trees it is difficult to form an accurate impression of the crown spread of the original stand. As an approximation the crown spread of the least deteriorated trees in the study area in the Park was plotted against the stem diameter at breast height and appeared to show a linear relationship which may be interpreted as 20 feet of crown diameter for every 1 foot of stem diameter. On this basis the crown cover of the original woodland is estimated as 21,770 sq. yds. or 4.5 acres, 28% of the total of 16 acres. This is three times the present day figure, and is of course purely conjectural.

With the decay of the former eucalypt overwood, canopy dominance is now assumed by the lower stratum of *Banksia spp.* and *Casuarina fraseriana* (Sheoak) which attains only 25 feet in height. It seems probable that the members of this stratum have increased in numbers since stand degradation set in. All these trees in the 24 x ½ acre plots of the vegetation management experiment were counted, taking as trees all specimens over 6 feet in height, and the figures set out in the accompanying table. The three species of banksia present *(B. grandis, B. menziesii* and *B. attenuata)* were not enumerated separately since *B. grandis* is relatively rare and the other two intermingle freely and appear to be ecologically equivalent. Stocking is variable but the average per acre is as follows (in round figures):—

Tuart	trees	8	=	9	5%
	saplings	1			
Jarrah	trees	4	=	7	4%
	saplings	3			
				—	—
	TOTAL EUCALYPTS			16	9%
Banksia		69			39%
Casuarina		92			52%
Other		1			—
		—		—	
	TOTAL ALL SPECIES			178	

This estimate is based on 12 acres instead of the 16 used for the eucalypt enumeration cited earlier but the number of eucalypt trees (disregarding saplings) is the same per acre. The enormous preponderance in numbers of the banksias and casuarinas over the eucalypts is most striking, as is the scarcity of eucalypts in the sapling stage.

A few of the tuart saplings—3 or 4 in the area studied—appear vigorous and in good condition and may be fairly recent seedlings. The rest, and all the jarrah, are as wretched and full of dieback as the older specimens of their species. Many, especially jarrah, have obviously been burnt back repeatedly and consist of clumps of cop-

pice. If the eucalypt community as a whole were in normal healthy condition, the amount of regeneration present would actually be adequate, but as things are the young individuals are clearly not on their way up to restore eucalypt dominance. They share in the general deterioration. Banksia and casuarina on the other hand can be seen regenerating in open spaces and (depending on frequency of fires) may be maintaining their populations. These two elements intermingle freely but a tendency to form pure groups is also noticeable. The conditions of their regeneration appear to be somewhat different and would account for this. Casuarinas frequently form dense thickets and once established are very hardy and persist for many years. A dead one (in the absence of fire) is hardly ever observed and many specimens live to a great age. Banksias on the other hand regenerate and establish more freely, and are relatively short-lived so that the bush is full of dead individuals which have succumbed naturally, especially in the summer. Both banksia and casuarina are hardy to fire and well withstand severe crown fires which destroy not only their leaves but the smaller branches as well.

It is very difficult to obtain an estimate of the crown cover of the *Banksia-Casuarina* stratum since the stand is so irregular, but with 160 individuals per acre and a probable mean cover of about 15 sq. yds. each, the total cover would be approximately 50%. The stratum is not a closed one except locally in thickets.

It has been shown that the crown cover of the eucalypt stratum has been reduced to about a third of its probable original value, and observation suggests that crown cover of the lower story has increased in the process.

CAUSES OF DETERIORATION

It is easy enough to show what has happened to the King's Park woodland, but less easy to assign causes for the change. However, deterioration can only be due to adverse changes in environmental factors, either climatic, edaphic or anthropogenic. It is difficult to envisage any adverse changes in the first two, so that the anthropogenic factor must be responsible.

It is believed that the early settlers of Perth felled jarrah in the Park for building purposes, but there is no evidence that tuart was worked to any extent. Felling of jarrah must have taken place a very long time ago, probably before 1871 when the first part of the Park was reserved, and certainly not after 1890 when the Park was consolidated and placed under management. The fellings may, however, have initiated the cycle of deterioration. Otherwise the principal disturbance factor has been the bushfire.

It is known that Aborigines used to burn off the country but we have unfortunately no detailed information about their practice. Fires are also set by lightning, and used to arise from this cause. The primitive or "original" woodland of King's Park grew up in equilibrium with the fire pattern of its early days, and subsequent changes in the fire pattern would tend to evoke changes in the vegetation. What has happened is that low-canopy dominance has replaced high-canopy dominance. An equilibrium between a tall eucalypt stratum

and a sparse understory has been replaced by another in which a dense understory is dominant to the exclusion of tall eucalypts.

The writer suggests that the sequence of events may have been as follows:—

1. Early settlers opened the canopy by felling jarrah. This stimulated the understory.
2. Fires became less frequent but more destructive due to more fuel and so damaged eucalypt canopy more.
3. The canopy was progressively more and more opened, and the undergrowth became denser and thicker between fires.
4. Eventually the increased number of understory trees came to compete for moisture in summer with the eucalypt dominants which died back progressively.

As far as can be ascertained, dieback of the eucalypts first became noticeable in the 1920s, and began to accelerate in the 1930s. At that time it seems that resources for firefighting were somewhat limited, and fires in severe weather would have been difficult or impossible to control. During the administration of Superintendent J. E. Watson from 1938, firebreaks and mechanical firefighting equipment were introduced and a policy of controlled burning-off in cool weather. These measures undoubtedly reduced fire damage but none the less it was during this period that the eucalypts became worst affected. The reason for this, it is suggested, may have been that copious regeneration of banksia and casuarina had already followed earlier fires. Protection allowed these to grow up into a dense layer that could compete too strongly with the eucalypt overwood. Protection, in other words, coming at this juncture, administered the final blow.

MEASURES OF REHABILITATION

It is assumed as a desirable object of park management that the process of deterioration in the bush should if possible be arrested and reversed. It could be desirable to recreate the character of the primitive woodland in selected areas, and basically the problem—which is to restore only 12 healthy tuart and jarrah trees per acre—might appear a simple one. However, replanting which had been done sporadically over the past 25 years has hardly added one new healthy dominant to the Park bush. Young trees can be established easily enough, but it has been found that after only a few years they become stagnant; any tuarts among them are attacked by insects and go into a decline. Marri *(E. calophylla)* remain healthy but grow slowly. In any case all of them have been subjected to fire damage.

It has been found in studies of tuart regeneration in the forest at Ludlow (Mr. G. E. Brockway, private communication) that the species will regenerate vigorously on ashbeds but is soon susceptible to the competition of established surrounding trees and declines as in King's Park. In open, cleared plots, however, young tuart will continue to make good, healthy progress. Evidently, therefore, there are two requisites to success—freedom from competition and from bushfires.

Experiments in King's Park over three years have now sueeeeded in developing a teehnique for sueeessful mass establishment of six to nine month old seedling trees. If planted in natural gaps in the bush eanopy whieh have been eultivated by rotary hoe, these will survive the following summer and make good growth, without watering or attention, and even if apparently drought-tender speeies like *E. diversicolor* (karri) and *E. guilfoylei* (tingle) are ineluded. Height growth and luxurianee are mueh improved by dressings of organie manure.

It is thought that healthy trees, therefore, ean be grown in the Park bush if they are properly treated and fire-protected.

It will be neeessary to eontinue experiments for some years, planting out groups of young tuarts, jarrah and marri, manuring and tending them, and gradually removing eompetition by banksia and easuarina from their vieinity. This will neeessitate vigorous progressive felling of the latter, but we already know from past experienee that unless this is done the euealypts eannot be expeeted to make good growth. Mowing of the ground vegetation around the groups of trees will be relied on for fire protection.

OCCURRENCES OF THE DOUBLE-BANDED DOTTEREL IN WESTERN AUSTRALIA

By JULIAN FORD, Perth.

The Double-banded Dotterel *(Charadrius bicinctus)* is a New Zealand breeding speeies whieh during the post-breeding period virtually deserts the South Island, and eongregates on the North Island, while a eonsiderable proportion of birds migrates across the Tasman Sea to eoastal eastern Australia, Tasmania and South Australia where a small number of non-breeding birds remain during the normal nesting season (W. B. Oliver, *New Zealand Birds*, Wellington, 1955, p. 259). Some birds penetrate many miles inland in eastern Australia (J. Hobbs, *The Emu*, 61, 1961: 30; 56, 1956: 434). It also visits Lord Howe, Norfolk and the New Hebrides Islands, and on rare oeeasions a few wander along the south eoast as far as South-western Australia (D. L. Serventy and H. M. Whittell, *Birds of Western Australia*, Perth, 1962, p. 190), where it has been observed at six loealities. Beeause of some eonfusion regarding these few known oeeurrenees in Western Australia, plus the faet that details of several speeimens eolleeted in the State have never been publieised, all definite sightings of the Double-banded Dotterel ineluding a reeent reeord are listed.

Point Malcolm, east of Esperance. J. T. Tunney eolleeted three speeimens—two males and one female—at Point Maleolm on June 16/17, 1906. The two males, one being in breeding plumage and the other in advanced moult into breeding plumage, are now in the Ameriean Museum of Natural History (nos. 736952/3), while the female, whieh is in eclipse plumage, is in the W.A. Museum (no. 8921).